Trends in Spawning Gravel Fine Sediment Levels—Deschutes River, Washington

John Konovsky and Joe Puhn, Squaxin Island Tribe

Introduction

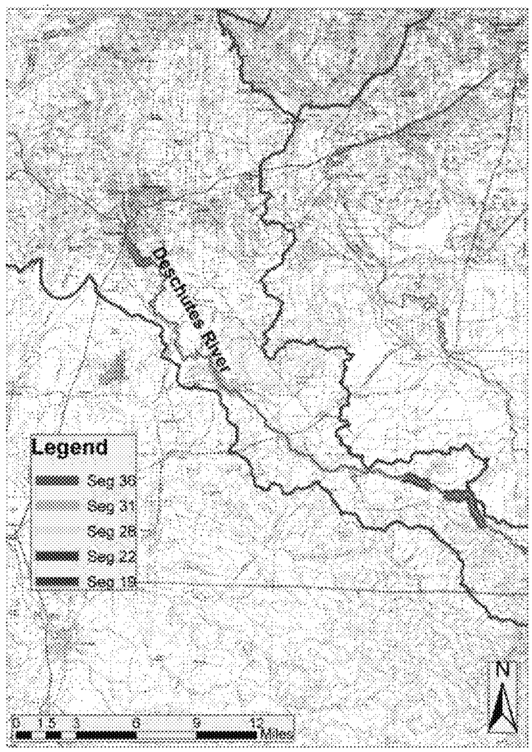
The Squaxin Island Tribe maintains a Steven's Treaty interest in the Deschutes River Watershed south of Olympia, Washington. The Deschutes River supports several salmonid species to an impassible falls at RM 41. The river is water quality impaired and on the State of Washington's 303(d) list for stream temperature, fecal coliform bacteria, large woody debris, stream flow and fine sediment.

As part of a Washington State Department of Ecology TMDL technical study, the Squaxin Island Tribe was asked to investigate the fine sediment impairment. EPA awarded the Squaxin Island Tribe $30,000 through the TMDL grant program to support the effort.

To look at trends in levels of fine sediment in spawning gravel, a 1995 investigation reported in Schuett-Hames & Child 1996 was repeated. The previous investigation assessed fine sediment levels in spawning gravel at the same five locations used in this follow-up study. All five sites are distributed along the mainstem of the Deschutes River from near the falls to the mouth.

In the earlier study, mean fine sediment levels (< 0.85 mm) ranged from 15.4% to 22.5%. The watershed analysis resource condition index for spawning habitat quality rates < 12% as good, 12-17% as fair and > 17% as poor (Washington Forest Practices Board 1995). In 1995, four of five segments were ranked as poor for excessive fine sediment.

Deschutes River
Segments for Graveling Sampling



Methods

The procedures for completing a spawning gravel composition survey are detailed in Schuett-Hames et al 1999—these methods are identical with the procedures used by Schuett-Hames & Child 1996.

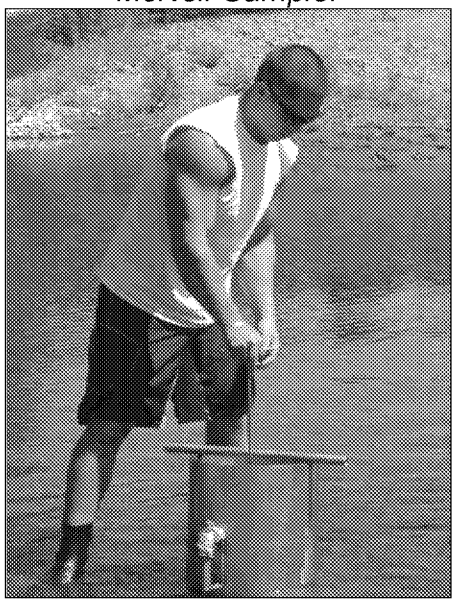
During late summer 2004, spawning gravel samples were collected at five sites on the mainstem of the Deschutes River.

Collection Locations

River Segment	River Mile	River Location	1995 gravel samples	2004 gravel samples
19	33.0-35.7	Weyerhaeuser	21	15
22	28.5-29.5	Lake Lawrence	16	14
28	20.8-22.0	Hwy 508	18	14
31	15.0-17.5	Waldrick Road	17	12
36	02.5-04.5	Pioneer Park	18	14

A riffle crest site inventory procedure was used to collect gravel samples. All spawning sites in each segment were inventoried and a subset of riffle crests sampled for gravel composition. Three gravel samples were collected at each riffle crest site, unless a portion of the cross-section did not contain suitable substrate. Using randomization procedures outlined on pages 20-21 and in Tables 3-4 of Schuett-Hames et al 1999, sufficient riffle crests were sampled to obtain a minimum of twelve gravel samples for each segment. A McNeil sampler was used to collect the gravel and the samples were stored in sealed plastic buckets with labels. A total of sixty-nine samples were collected.

McNeil Sampler



To process the samples, a volumetric method was used per Schuett-Hames et al 1999, pages 6-7. Gravel samples were shaken and washed to allow smaller particles to move downward through a stack of sieves until they were retained on a sieve corresponding to their proper particle size class. The sieve openings ranged from 75 mm to 0.106 mm. Particles too small to collect in the 0.106 mm sieve were captured in a graduated cylinder attached to the bottom of a settling basin. The volume of sample particles retained on each sieve was measured by displacement.

For statistical analysis, a two-factor (location and year), fixed effects ANOVA model was run without any data transformations after Levene's test for the equality of group variance was applied to the percentage data. Scheffe's multiple comparison procedure was used to compare locations.

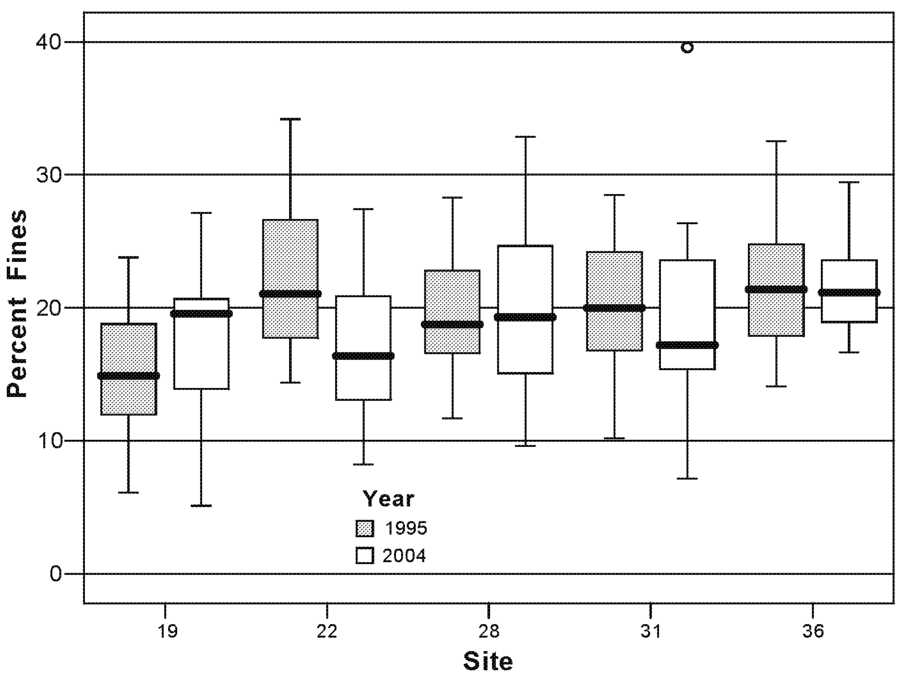
Results/Discussion

Summaries statistics are presented in Table 1 and Figure 1.

Table 1. Summary statistics for mean percent fines by LOCATION and YEAR.

Year	Location	Mean Percent Fines	Sample Size	Standard Deviation	Coef. of Variation	Standard Error	Median	Minimum	Maximum
1995	19	15.4%	21	4.58%	29.74%	1.00%	14.9%	6.1%	23.8%
	22	22.5%	16	6.14%	27.29%	1.54%	21.1%	14.4%	34.2%
	28	19.4%	18	4.88%	25.15%	1.15%	18.8%	11.7%	28.3%
	31	19.9%	17	4.96%	24.92%	1.20%	20.0%	10.2%	28.5%
	36	22.0%	18	4.85%	22.05%	1.14%	21.4%	14.1%	32.5%
	Total	19.6%	90	5.60%	28.57%	0.59%	18.8%	6.1%	34.2%
2004	19	17.3%	15	6.14%	35.49%	1.59%	19.6%	5.1%	27.1%
	22	17.0%	14	5.80%	34.12%	1.55%	16.4%	8.2%	27.4%
	28	20.2%	14	7.05%	34.90%	1.88%	19.3%	9.6%	32.9%
	31	19.5%	12	8.18%	41.95%	2.36%	17.2%	7.2%	39.6%
	36	22.0%	14	3.94%	17.91%	1.05%	21.2%	16.6%	29.4%
	Total	19.2%	69	6.41%	33.39%	0.77%	19.1%	5.1%	39.6%
Combined	19	16.2%	36	5.28%	32.59%	0.88%	16.1%	5.1%	27.1%
	22	19.9%	30	6.52%	32.76%	1.19%	19.2%	8.2%	34.2%
	28	19.8%	32	5.84%	29.49%	1.03%	18.8%	9.6%	32.9%
	31	19.7%	29	6.35%	32.23%	1.18%	18.3%	7.2%	39.6%
	36	22.0%	32	4.41%	20.05%	0.78%	21.4%	14.1%	32.5%
	Total	19.4%	159	5.95%	30.67%	0.47%	18.9%	5.1%	39.6%

Figure 1. Box-and-whiskers plot comparing percent fine measurement for locations sampled by year.



Using a two-factor (location and year), fixed effects ANOVA model and Levene's test for the equality of group variances, the hypothesis that the data have homogeneous group variances could not be rejected ($P = 0.386$). This means that a two-factor ANOVA without any data transformations can be used to analyze the percentage data. This is an unusual situation, but probably due to the fact that the data for each of the groups (location-year combination) had a relatively small spread and the group means were very similar.

The two-factor ANOVA model tested was the full model including the location X year interaction: The ANOVA table summarizing this model is presented in Table 2.

Table 2. ANOVA for mean percent fines by LOCATION and YEAR: test of between subjects effects..

Dependent Variable: PerFines (Design: Intercept+site+year+site * year)

Source	Type III Sum of Squares	Degrees of Freedom	Mean Square Error	F Statistic	Significance
Corrected Model	.086(b)	9	0.010	3.013	**0.002**
Intercept	5.915	1	5.915	1862.410	**0.000**
site	0.054	4	0.014	4.259	**0.003**
year	0.002	1	0.002	0.514	0.475
site * year	0.026	4	0.006	2.019	0.095
Error	0.473	149	0.003		
Total	6.563	159			
Corrected Total	0.559	158			

a Computed using alpha = .05
b R Squared = .154 (Adjusted R Squared = .103)

This model is significant in explaining the variability of the data ($P = 0.002$). The site (location) factor is significant ($P = 0.003$) while the year factor is not ($P = 0.475$). The interaction (location X year) was not significant ($P = 0.095$).

Therefore, we conclude there is no difference between years but there is a difference among locations in mean percent fines.

Figure 2 compares the model-adjusted means by location. The means are adjusted by the ANOVA model (intercept+site+year) to account for any year effects. Scheffe's multiple comparison procedure was used to compare locations because it is a conservative test and the comparisons were unplanned. The only sites that were found to be significantly different from each other ($P < 0.01$) were sites 19 and 36.

Figure 2. Mean percent fines by location with 95% confidence intervals. The means are adjusted by the ANOVA model (intercept+site+year) to account for any year effects.

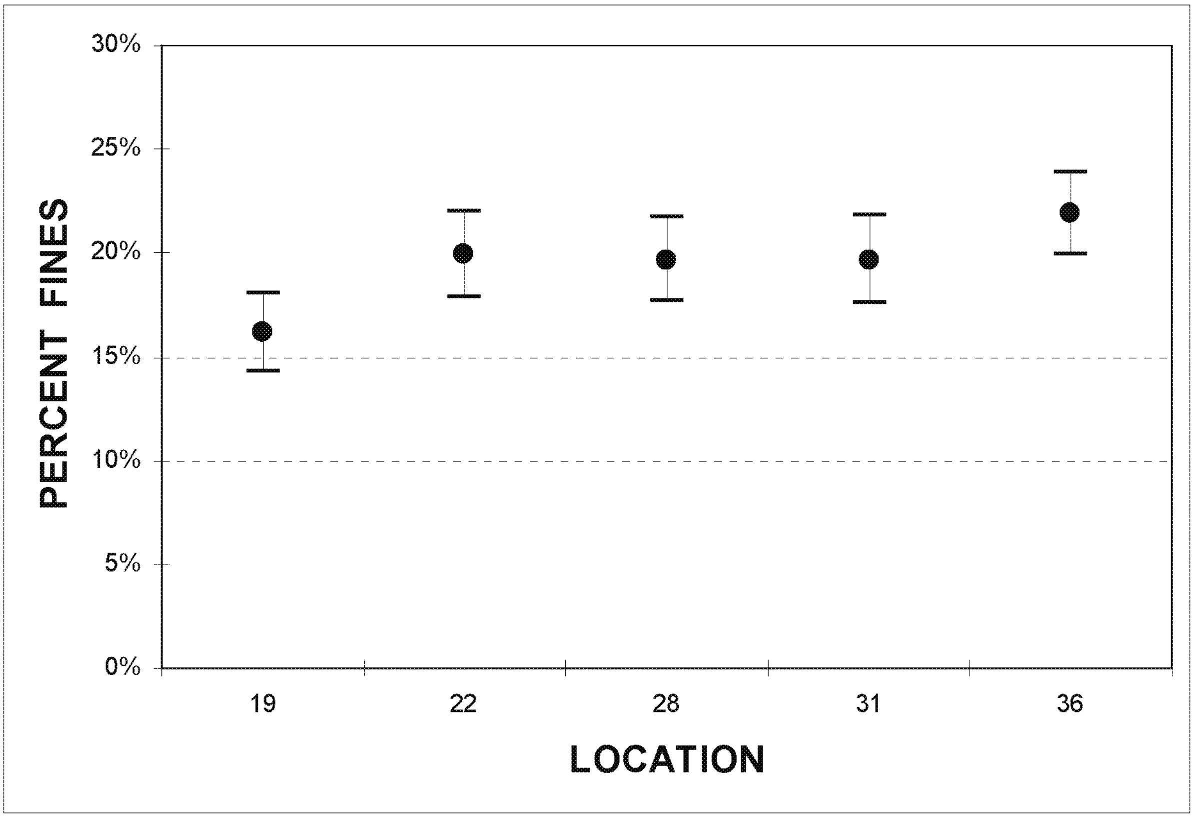


Table 3: Fine Sediment Summary

Deschutes Spawning Gravel			Fine Sediment < 0.85 mm				Watershed Analysis Evaluation		
Segment	RM	Location	1992	1995	2004	Mean	1992 Condition	1995 Condition	2004 Condition
19	33.0-35.7	Weyerhaeuser	11.6%	15.4%	17.3%	16.4%	good	fair	poor
22	28.5-29.5	Lake Lawrence		22.5%	17.0%	19.7%		poor	fair
28	20.8-22.0	Hwy 508		19.4%	20.2%	19.8%		poor	poor
31	15.0-17.5	Waldrick		19.9%	19.5%	19.7%		poor	poor
36	2.5-4.5	Pioneer		22.0%	22.0%	22.0%		poor	poor
			Mean	19.6%	19.2%	19.4%		poor	poor

Table 3 includes data from a spawning gravel analysis for segment 19 collected in 1992 (Schuett-Hames & Flores 1994).

Overall the results suggest that fine sediment levels in spawning gravel have been consistent over the last 10 years. No significant differences were found between years. General conditions are poor with a mean of about 19.4% fine sediments. No change is evident from forestland management practices that changed with the 1999 adoption of the Forest Practices Act (Chapter 76.09 RCW) and Forest Practices Rules (Title 222 WAC).

There are significant differences between sites when two years data are adjusted for year effects and averaged across years for each site. There is a weak trend of increasing fine sediment downstream. The uppermost site has a lower level of fine sediment in spawning gravel and the lowest site is higher. Such a trend is not unexpected—the river begins with bedrock as a substrate, then continues down through the mid-section where agricultural activity has damaged the riparian zone. The increase in agricultural activity and associated damage to riparian zones may result in accelerated erosion and higher fine sediment levels downstream.

The uppermost site (19) has three years of data available and demonstrates a trend of increasing fine sediment from 1992 to 1995 and 2004. In 1992, it met the watershed analysis standard of < 12% fines in spawning gravel and was rated as good in condition. The fine sediment increase may have been caused by a January 1990 100+ year storm event that hit the upper Deschutes, several miles above the site (Toth 1991). A significant sediment load was unleashed during that storm. The fact that the level continues to increase may mean the 1990 sediment slug is still in the upper watershed and working its way down. Alternatively, site 19 is heavily used by all-terrain vehicles. They drive up and down the river bed and along the banks in the summer time. In the area of site 19, anecdotal observations suggest that ATV activity has accelerated soil erosion rates and may supplement or have replaced storm-related soil erosion as the primary source of fine sediment in spawning gravel.

Recommendations

The data presented in this report suggest that additional reduction in fine sediment levels in spawning gravel is necessary to achieve a watershed analysis resource condition index rating of "good." Such an achievement is required for the Deschutes River fisheries to be fully productive and supportive of Squaxin Island Tribe Treaty Rights.

As a first step toward fine sediment reduction, ATV use around site 19 should be controlled or eliminated. That responsibility falls primarily to the industrial timber company that owns the land. They should use their authority to control access and use. A secondary role may fall to the State of Washington to enforce nonpoint pollution laws triggered by the anthropogenic origin of at least some of fine sediment.

The Deschutes does need to be recognized as a relatively young river system prone to high rates of soil erosion because it formed in glacial geology from the Vashon Stade, which ended about 11,000 years ago (Collins 1994). Preliminary results from an analysis underway (Raines, in preparation) suggest, though, that anthropogenic contributions of fine sediment average about 50% watershed-wide and may be higher in the upper watershed because of the extensive, unpaved forest road system. If these preliminary conclusions hold, they suggest that improvements are possible in forest and land management practices that will lower fine sediment levels in spawning gravel and benefit fisheries. This is particularly critical in the upper watershed where most salmonid species spawn.

Improvements in the forest road system implemented after adoption of the Forest Practices Act and Rules are evident. However, we expect a significant lag time before these improvements might show measurable benefits in the field. Our final recommendation is to remeasure fine sediment in spawning gravel at the five sites used in this study in 2014. If no improvements are noted particularly in the upper watershed, a re-evaulation of the effectiveness of the Forest Practices Act and Rules is warranted.

Bibliography

Collins, B. 1994. *A Study of the Rates and Factors Influencing Channel Erosion along the Deschtues River, Washington with Application to Watershed Management Planning*. Squaxin Island Tribe, Shelton.

Raines, M. In preparation. *Deschutes River Mainstem Bank Erosion: 1991-2003*. Squaxin Island Tribe, Shelton.

Schuett-Hames, D. & I. Child. 1996. *An Assessment of Stream Temperature, Large Woody Debris Abundance and Spawning Gravel Fine Sediment Levels in the Mainstem Deschutes River*. Squaxin Island Tribe, Shelton.

Schuett-Hames, D., R. Conrad, A. Pleus & M. McHenry. 1999. *TFW Monitoring Program Method Manual for the Salmonid Spawning Gravel Composition Survey.* Prepared for the Washington State Department of Natural Resources under the Timber, Fish and

Wildlife Agreement. Northwest Indian Fisheries Commission, Olympia (www.nwifc.org/TFW/documents/tfw-am9-99-006.asp).

Schuett-Hames, D. & H. Flores. 1994. Final Report: *The Squaxin Island Tribe/Thurston County Streambed Characterization Contract: 1992-93.* Squaxin Island Tribe, Shelton.

Toth, S. 1991. *A Road Damage Inventory for the Upper Deschutes River Basin.* SHAMW Committee, Olympia.

Washington Forest Practices Board. 1995. *Forest Practices Board Manual: metholdogy for conducting watershed analysi*s. Department of Natural Resources, Olympia.

Acknowledgements

Thanks to Allen Pleus for project consultation and to Robert Conrad for statistical analysis review—both work for the Northwest Indian Fisheries Commission. Thanks also to the field crew led by Joe Puhn and assisted by Josh Henderson, Ben Parker, Tracy Farrell and Scott Steltzner.